

V-3. TELECOMMUNICATIONS AND EDUCATION COST SAVINGS IN ARKANSAS

Arkansas-specific education expenditures are defined as the sum of total government outlays for education and expenses incurred by private education providers. Government expenditures on education are recorded either as direct expenditures or "intergovernmental" expenditures. The latter describes transfers from one governmental level to another. Those funds which flow between governments are recorded separately as intergovernmental revenue and intergovernmental expenditure. Therefore, to avoid duplicative counting, DRI defines total government expenditures on educational services as direct state-level expenditures, plus direct local expenditures, which reflect all relevant intergovernmental transfers. In Arkansas, public education expenditures totaled \$2.32 billion in 1991, and grew at an annual rate of 8.4% since 1977.

While state-specific private expenditures on educational services is not readily available, if the ratio of Arkansas private to public education expenditures is assumed to equal this ratio at the national level, private expenditures in Arkansas may be estimated. This procedure indicates that public and private education spending in Arkansas totaled \$2.79 billion in 1991. Again, assuming telecommunications reduced education costs in Arkansas in the same proportion as cost reductions to total U.S. education, advances in telecommunications production and consumption reduced 1991 Arkansas education costs by about \$33.3 million. The cumulative savings enjoyed by the Arkansas economy over the entire 1977 to 1991 interval totaled \$239 million in 1991 dollars.

Table V-3-1

*Summary of Arkansas Health Care and Education Savings
Due to Telecommunications Advances
(millions of 1991 dollars)*

Industry	Medical Services	Educational Services
Total Costs	4,724.4	2,789.6
Percent Cost Savings in 1991	0.70	1.19
1991 Savings	32.8	33.3
Cumulative 1972-1991 Svgs	233.1	238.6

V-4. FINDINGS AND OBSERVATIONS

This section reviewed the additional positive impact telecommunications has had on issues now at the top of the public policy agenda: the costs of providing health care and educational services. Key findings are summarized below:

- Assuming telecommunications reduced education costs in Arkansas in the same proportion as cost reductions to total U.S. education, advances in telecommunications production and consumption reduced 1991 Arkansas education costs by about \$33.3 million. The cumulative savings enjoyed by the Arkansas economy over the entire 1973 to 1991 interval totaled \$238.6 million in 1991 dollars.
- Assuming telecommunications reduced health care costs in Arkansas in the same proportion as cost reductions to total U.S. health care, advances in telecommunications production and consumption reduced 1991 Arkansas health care costs by about \$32.8 million. The cumulative savings enjoyed by the Arkansas economy over the entire 1973 to 1991 interval totaled \$233.1 million in 1991 dollars.

VI. IMPACTS ON SPECIFIC STAKEHOLDER GROUPS

As part of DRI's analysis, the effects of telecommunications modernization on subgroups of the Arkansas population have been examined. The purpose of this phase of the study is to quantify the benefits of telecommunications modernization on individual consumer groups in Arkansas. These groups often provide views on the likely consequences of changes in telecommunications policy. While the anecdotes and figures that these consumer groups present are important components to the policy making process, it is difficult to use these scattered anecdotes to determine--on a consistent basis--the likely benefits of modernization to each consumer group. Hence, DRI developed a quantitative framework that estimates, on a consistent basis, the likely impact of telecommunications modernization on individual consumer groups. The groups include: low-income residents (the lowest 20% ranked by income per household), high-income residents (the highest 20% ranked by income per household), and the elderly (over 65). Our results show that all of the population subgroups enjoy greater purchasing power as a result of telecommunications infrastructure modernization.

As discussed in Chapter II of this report, DRI has demonstrated the historical significance of telecommunication infrastructure to U.S. economic vitality. The period since the early 1960s was characterized by heavy investment in expanding and modernizing the U.S. telecommunications infrastructure. The telephone companies deployed technological innovations under the supervision of state and federal regulatory agencies, paying particular attention to the impact on telephone customers and the expected economic benefits of the new technologies. The U.S. continued as the world leader not only in the quality of its telecommunications network, but in its relative prices and the availability of service. Meanwhile, the economy experienced a structural transition away from manufacturing and primary production toward telecommunications-intensive services, further increasing demand for a sophisticated and efficient telecommunications network.

The advancement in the quality of telecommunications and the decline in real telecommunications prices contributed to a dramatic increase in the consumption of telecommunications services. From a broader social viewpoint, however, the significance is the additional resources made available as telecommunications usage displaced less efficient and more costly resources.

With estimates of telecommunications induced resource savings across industry sectors, it is possible to estimate the savings to individual consumer groups resulting from telecommunications-induced efficiency gains in the past. By matching consumer purchasing patterns by industry with estimates of resource savings by industry we can estimate how individual consumer subgroups are affected by this increased usage of telecommunications since 1977. We estimate the increased purchasing power by assessing how much each consumer group would have had to have spent in 1991 to purchase the same mix and quantity of goods and services, if telecommunications had not advanced since 1977. For example, the financial services industry was able to reduce costs by 3.0% as a result of telecommunications advances over the 1977 to 1991 period. If these

advances had not take place, the price for financial services may have been higher in 1991 than it actually was. As a result consumer groups which spend a high percentage of their income on financial services would have had to spend more money to buy the same amount of financial services that they did in 1991. Thus, their spending power would be reduce if it were not for telecommunications advances.

The results show that the purchasing power of the average household in Arkansas was 1.3% higher in 1991 than it would have been were it not for improvements in telecommunications.

VI-1. THE ELDERLY GROUP

A modernized telecommunications network has the potential to improve the lives of the elderly through (1) increased access to services and (2) lower prices. Telecommunications infrastructure modernization potentially lowers the prices of goods and services in the economy. The impact on the elderly of lower prices on all goods and services is a function of the elderly's purchases of non-telecommunications goods and services. The more efficient use of telecommunications allows producers to substitute telecommunications for costlier, less efficient inputs. The producers, in turn, can lower their prices due to the efficient substitution of telecommunications. Therefore, the elderly's cost savings due to telecommunications-induced efficiency gains are indirectly derived through price reductions in the goods the elderly buy in combination with the percentage of their income that is spent on each of these goods. These price savings are especially important to the elderly population, who are frequently on fixed incomes.

Increased access to services is less quantifiable--but nonetheless important. Some services provided through an advanced telecommunications network have the potential to "help a senior citizen remember appointments or when to take medication, tell them news, monitor their health, or call a person or institution in case of an emergency."²² Telecommunications networks also make possible new services like SeniorNet which offers news services, bulletin boards, databases, financial and travel services, shopping, event schedules, electronic mail, and a member directory to elderly computer users.²³ The development of a supportive infrastructure may allow services like this to grow, and possibly become video-interactive. For home-bound senior citizens, these services provide an additional opportunity to socialize and survive independently.²⁴ Cost and its distribution across income groups is an issue in the development of new telecommunications services. The American Association of Retired Persons (AARP), for example, while not opposing the development of new telecommunications services, is concerned that the elderly will be charged for services they do not use and that these costs will jeopardize the affordability of basic telephone service.²⁵

DRI examines the cost savings enjoyed by the elderly by assessing (1) the mix of goods they buy, (2) the efficiency with which each of those industries substitute telecommunications for other, costlier inputs and (3) the extent to which each of these industries passes on these cost savings to the consumer. The analysis shows that elderly households may potentially lag behind the average household in terms of benefits accrued due to increased telecommunications efficiency. Elderly households consume

²² Wallys W. Conhaim, "Videotex: Beneficial for the Elderly" *Information Today*, April 1989, p.26.

²³ Ibid., p. 27.

²⁴ Clare Ansberry, "Love Affairs Loom Amid Bits and Bytes of Home Computers" *Wall Street Journal*, Feb 28, pages A1 and A9.

²⁵ American Association of Retired Persons. *Toward a Just and Caring Society* 1992, page 208.

proportionately fewer telecommunications-intensive applications than the average household.

For example, elderly households consume less financial services--6.2% of income--than the average household--12% of income (see *Table VI-1-1*). The fact that elderly households consume half of what the average household consumes of financial services affects the benefits they receive from telecommunications-induced efficiency gains because, historically, the financial services sector has been able to reduce its production costs by 2.5% due to telecommunications. This cost saving is significantly higher than the Arkansas economy-wide average of 1.2% (see *Table III-1-1*). Therefore, by consuming less financial services, the elderly do not receive the same indirect benefits that other households receive due to telecommunications-induced efficiency gains in the financial services industry. Elderly households also consume less electric and electronic equipment than the average household consumes. Since this sector was also able to significantly reduce its production costs due to telecommunications, elderly households do not receive the same benefits that other households receive due to telecommunications-induced efficiency gains. Conversely, elderly households consume nearly 50% more than the average household consumes of medical and miscellaneous services, an area where telecommunications applications may not have been fully exploited in the past. As a result of these relationships, telecommunications-induced efficiency gains increased the spending power of the elderly by 1.1% in 1991, or \$154. Hence, elderly households have clearly benefited from telecommunications induced efficiencies, although to a lesser extent than the average household.

Table VI-1-1
Consumer Expenditures for Elderly Households
Compared to the Average Household

	Elderly		Average	
	%	1991\$	%	1991\$
Housing	15.8%	3119	17.5%	5191
Food	17.2%	3383	16.4%	4844
Financial Services	6.2%	1215	12.4%	3683
Medical and Other Misc. Services	13.8%	2724	8.3%	2449
Motor Vehicles and Equipment	5.6%	1109	7.1%	2111
Textiles	5.7%	1132	6.6%	1950
Electric & Electronic Equipment	4.7%	932	6.0%	1785
Utilities	6.8%	1339	4.6%	1372
Petroleum Refining	3.0%	600	3.4%	995
Business Services	2.9%	572	2.9%	860
Automotive Repair	2.8%	552	2.9%	845
Amusements	2.7%	533	2.6%	777
Telecommunications	2.2%	440	2.1%	618
Transportation and Warehousing	1.2%	233	1.0%	304
Chemicals and Products	1.3%	256	1.0%	301
Furniture	0.7%	139	1.0%	294
Printing and Publishing	0.7%	144	0.6%	163
Paper and Paperboard	0.6%	125	0.4%	123

Source: Bureau of Labor Statistics Consumer Expenditure Survey and DRI/McGraw-Hill

VI-2. THE HIGH- AND LOW-INCOME GROUPS

As in the case of elderly households, low-income households in Arkansas tend not to consume telecommunications-intensive applications as much as other households. For instance, they do not spend a large proportion of their income on financial services, electric and electronic equipment, and business services and therefore do not benefit as much as the average household from telecommunications modernization. As a result, telecommunications-induced efficiency gains increased the spending power of low income households by 1.1% in 1991, or \$114. Despite their comparatively low consumption of telecommunications-intensive applications, low-income households derive the benefits of telecommunications modernization through their purchases of other goods and services, such as medical services.

Conversely, the high-income group will realize a slightly greater benefit since they consume more telecommunications-intensive applications than the average household. For example, they spend more on telecommunications-intensive applications as a proportion of their total expenditures than most people.²⁶ When these factors are taken into account, the DRI analysis shows that the wealthiest 20% of the population has enjoyed the greatest increase in spending power as a result of telecommunications advances. Telecommunications-induced efficiency gains increased the spending power of high income households by 1.4% in 1991, or \$576.

²⁶ Bureau of Labor Statistics Consumer Expenditure Survey, 1991, Tables 3, 1100, and 1700 and DRI/McGraw-Hill.

VI-3. FINDINGS AND OBSERVATIONS

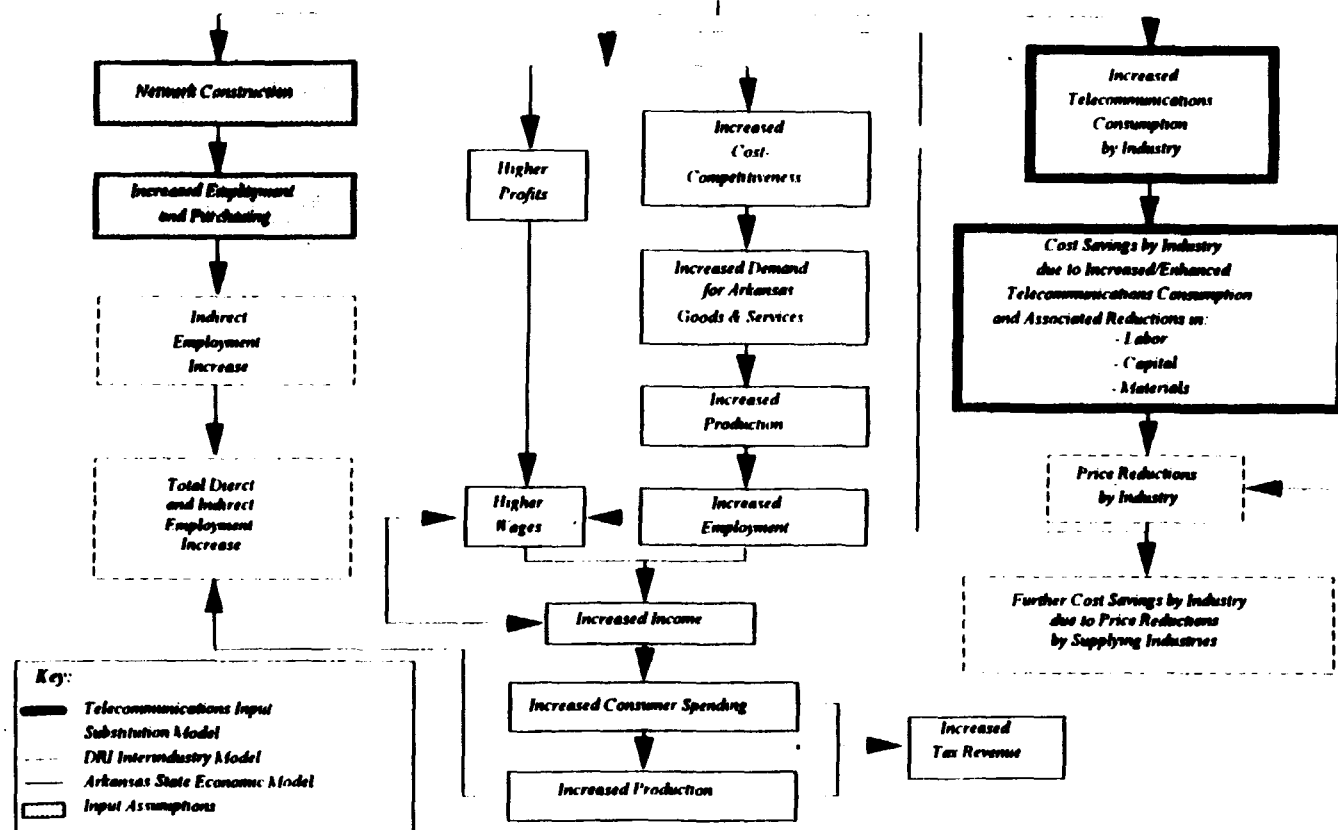
- Overall price reductions resulting from telecommunications advances are important to the elderly, since they often have fixed incomes. Moreover, telecommunications will improve access to community social and professional services at a relatively low cost.
- High-income groups derive proportionally greater benefits from improved telecommunications infrastructure than average. Despite their comparatively low consumption of telecommunications-intensive applications, low income households derive the benefits of telecommunications modernization through their purchases of other goods and services, such as medical services.

VII. METHODOLOGY

In producing its estimates, DRI employed its Telecommunications Infrastructure Modeling System. This system consists of three statistical models, each focusing on a different aspect of the relationship between telecommunications modernization and state-wide economic benefits. First, we developed the DRI Telecommunications Input Substitution Model, an industry-specific econometric models detailing how telecommunications is substituted for other inputs to the production process--namely, labor, capital, and materials. DRI used this model to estimate the direct cost savings in each of 30 Arkansas industries due to increased telecommunications usage. Second, DRI employed its Interindustry Model to reflect Arkansas-specific telecommunications consumption levels and to measure the degree to which each industry is able to pass its own cost savings on to other industries. Finally, DRI employed the Arkansas State Model, an econometric model of the state of Arkansas, to quantify the effect of these industrial cost savings on economic activity and wage rates, and thereby on job creation, income, and tax revenue. This model was also used to estimate multipliers--the degree to which an increase in employment tends to spur further employment.

This section contains a discussion of these three models, followed by an explanation of how and why they were essential to the analysis. *Figure VII-1* below illustrates the dynamic linkages among the elements comprising these models in the creation of DRI's Telecommunications Infrastructure Modeling System.

Figure VII-1
Arkansas Telecommunications Infrastructure Modeling System



VII-1. THE TELECOMMUNICATIONS INPUT SUBSTITUTION MODEL

DRI's Telecommunications Input Substitution Model measures the importance of telecommunications usage to an industry's ability to reduce its production costs. By estimating an entire system of equations for each of 30 industries, ranging from four to six equations per industry²⁷ we related each industry's usage of capital, labor, materials, and telecommunications to the prices of each input, the advancement in each input's technology, and the industry's production level. DRI estimated the equations econometrically in a translog framework using a technique known as the "dual", which is consistent with methodologies presented in publications by leading industrial econometricians.²⁸

Typically, the dual is used to study the effects of changes in energy costs or wage rates on production costs and input mixes. DRI is the first to apply this framework specifically to telecommunications usage. The dual is superior to other techniques used in productivity analysis because of its flexibility and its ability to consider a greater amount of information. For example, it can be used to analyze the input structures of individual industries rather than broad aggregations. In so doing, it takes account of both the industry's cost structure and its production function as well as the interplay between the two. The model can incorporate this information because it contains, for any industry, data on the price of each input and data on the degree to which the industry has substituted toward or away from any given input as relative input prices have shifted. For example, consider a rise in the price of labor relative to telecommunications. If a particular industry, such as the financial services sector, continually utilizes labor at the same rate as in the past, one can conclude that telecommunications is not a substitute for labor in the financial services sector. Similarly, if the financial services sector's usage of labor drops and its usage of telecommunications climbs, one can conclude that telecommunications is a viable substitute for labor. These relationships underlie the model's measurements.

In addition to input price and usage data, DRI included a measure of industry-specific production *levels*, in order to incorporate economies of scale into the system. We also included a time trend to take account of advancing technology and human knowledge. When deemed appropriate by statistical tests, DRI added a supply equation to the system to measure the degree of simultaneity between the price an industry charges--which is largely a function of its input costs--and the amount it sells.

Another example of the dual's flexibility is its ability to support "cross-term" variables. Cross-terms are combinations of explanatory variables included in the system not only individually but also multiplicatively. They serve to measure the effect of one individual variable on the explanatory power of another. For example, if the price of

²⁷ Francis J. Cronin, et. al., *The Contribution of Telecommunications Infrastructure to Aggregate and Sectoral Efficiency*, DRI/McGraw-Hill, February 1991.

²⁸ Ernst R. Berndt, *The Practice of Econometrics; Classic and Contemporary*, Reading, MA: Addison Wesley, 1991.

telecommunications and a technology variable are each included in the system together with their cross-term, the system will measure not only how each variable influences an industry's choice of inputs, but also how the influence of the price of telecommunications changes as technology advances. Thus, if an industry has been gradually learning how to make better use of telecommunications as a substitute for labor, the model will capture this trend. Similarly, the cross-term of an industry's production level and the price of capital provides information on the effect of economies of scale on an industry's reaction to shifts in the price of capital.

For each of 30 industries, DRI developed a set of systems of simultaneous equations that estimated the cost savings and shifts in input mix that would result from any specified change in input prices, production levels, or technology. DRI estimated the model at a quarterly frequency over the 1963 through 1991 period.

VII-2. THE INTERINDUSTRY MODEL

DRI used its Interindustry Model to estimate the ability of an industry to pass its cost savings on to other industries. The Interindustry Model details, for each of 30 industries, the amount each industry purchases from every other industry in order to produce a unit of output. Thus, it decomposes an industry's production processes into 30 separate materials and services inputs (including telecommunications services), as well as its primary inputs--labor and capital.

These precise interrelationships enable one to trace how a change in the production process in one industry ripples throughout the economy. For example, the Interindustry Model, quantifies the extent to which the real estate industry relies on inputs from the finance industry. This quantified dependence is a means for estimating how a decrease in costs in the finance sector would flow through to the real estate sector. The real estate industry realizes a slight indirect cost saving through the finance industry, beyond the direct impact of its own increased telecommunications consumption as estimated by the input substitution model.

Similarly, and of even greater importance to this analysis, the model can trace cost savings in one industry to cost savings throughout the economy. Suppose a modernized telecommunications network allows its users to cut production costs substantially. The input substitution model described earlier yields an estimate of each industry's own cost savings as a direct result of its usage of telecommunications. However, since this model is industry-specific, it does not indicate how other industries might benefit from this cost decrease. The DRI Interindustry Model must be used to estimate this indirect cost savings.

For example, suppose the input substitution model suggests that the real estate industry and the finance industry each experience a 1% per-unit real cost decrease due to increased consumption of telecommunications. Suppose further that finance passes these savings on to its customers, including the real estate industry. From the DRI Interindustry model, we know the extent to which the real estate industry relies on inputs from the finance industry. This provides us with a means for estimating how a decrease in costs in the finance sector would flow through to the real estate sector. The real estate industry realizes a slight indirect cost saving through the finance industry, above and beyond the direct impact of its own increased telecommunications consumption as estimated by the input substitution model.

Like the input substitution model, DRI's Interindustry Model takes a wide scope of information into account, since it is linked in a variety of ways to the DRI Macroeconomic Model. Thus, the Interindustry Model is driven by a comprehensive macro environment that includes specific projections of GNP, interest rates, inflation, wage rates, exchange rates, and population growth. For the purposes of this analysis, DRI built in a "dampening" effect to account for the fact that 1) not all cost savings will be passed on to the customer and 2) many supplies will continue to be imported from out of state, where Arkansas-specific cost savings will not be a factor.

VII-3. THE ARKANSAS ECONOMIC MODEL

DRI used the Arkansas Economic Model to estimate the extent to which network modernization and cost savings resulting from enhanced telecommunications usage spurred further employment, income, and tax revenue in Arkansas. The model is comprised of a system of approximately 150 econometric equations that quantify the importance of cost-competitiveness and industrial structure in Arkansas, relative to the rest of the nation.

The model links network modernization and job creation through three dynamics: producers' demand, producers' cost-competitiveness, and changes in personal income. Producers' demand changes when new technological developments require a new set of inputs.

Producers' cost-competitiveness changes when industries are able to lower their production costs, in this case by using modern telecommunications technology to offset other, more costly inputs. If they proceed to pass some or all of these cost savings on to their customers, they can pull market share away from out-of-state competitors constrained by outdated infrastructure. Even in industries where interstate competition is not a factor, cost-competitiveness can generate economic activity simply by stimulating spending that would not otherwise take place. Lower prices at restaurants, for example, may encourage more people to eat out. The Arkansas State Model quantifies the degree to which cost-competitiveness in the Arkansas economy generates business and employment.

Finally, changes in personal income occur as a result of changes in wage rates and employment levels. Both of these, in turn, result from changes in producer demands and producer costs. The Arkansas State Model takes these wage and employment changes as a starting point and proceeds to simulate the "multiplier" effect. Through the multiplier effect, increases in personal income encourage spending that otherwise would not take place. To support this new spending, consumer goods producers boost output, which means employing more people. All of this increased employment either reduces unemployment or induces job changes by the offering of higher wages. Either case again leads to greater discretionary income, which spurs more spending, and so on. The Arkansas State Model captures the full effect of this simultaneity.

In estimating the increase in discretionary income, the model also establishes the degree to which greater demand for labor and greater productivity of labor combine to put upward pressure on wages, offsetting some of the cost savings that would otherwise have been attained. The Arkansas Economic Model, in turn, estimates the degree to which wage increases might discourage hiring.

VII-4. Applications to the Arkansas Analysis

Historical Analysis: Efficiency Impacts

To estimate the employment, income, and taxes that are generated by the increased economic activity stemming from network-induced efficiency gains, DRI combined key aspects of all three models: the Telecommunications Input Substitution Model, the Interindustry Model, and the Arkansas Economic Model. DRI employed these models to compare the actual 1991 Arkansas economy to that which would have existed, had usage and production of telecommunications not changed since 1977. To make this comparison, we constructed an alternative 1991 interindustry model, which is identical to the actual 1991 model, except that: (1) we replaced the 1991 telecommunications production input mix with the 1977 mix; (2) for each of 30 industries, we changed the amount of telecommunications required to produce a unit of output in 1991 to the amount required in 1977; and (3) we increased the amount of alternative input requirements in order to offset the hypothetical lack of availability of advanced telecommunications.

To accomplish Step (3) above, we ran the Telecommunications Input Substitution Model on each industry to obtain an estimate of the amount of labor, capital, and materials that can be replaced by a dollar's worth of telecommunications purchased by a given industry. We then used these specific relationships to determine the mix of input requirements that each industry in the 1991 Arkansas economy would have faced, had it not been able to use telecommunications as a replacement for other, more costly inputs over the 1977-91 period. We made the corresponding adjustment to the interindustry model in constant dollars to avoid confusing input *technology* changes over time with input *price* changes over time. Because the telecommunications input substitution model was estimated on an industry-specific basis, we were able to make a unique adjustment to the input mix of each of the 30 Arkansas industries. Thus, for each industry, we obtained an estimate of the degree to which each industry would have faced higher production costs in the hypothetical 1991 economy, in which telecommunications production and usage had remained unchanged since 1977.

The difference between the production costs that would have been faced by industries in the hypothetical 1991 economy and the production costs *actually* faced by industries in 1991 represents the cost savings experienced by industries due to telecommunications advances since 1977. We then ran these industry cost savings through the DRI Interindustry Model to measure the extent to which each industry was able to pass its cost savings on to its customer industries, and the latter to their customer industries, and so on. (See the Interindustry Model discussion for an explanation of direct and indirect cost savings.)

DRI then ran the Arkansas Economic Model to estimate the impact of these industry-specific cost savings on jobs, income, and taxes. The model first established the link between cost-competitiveness and increased demand for the resulting lower-priced goods and services, and then generated the multiplier effect as described above. The model included a system of

relationships that measured the extent to which incremental demands for labor and goods and services were likely to be met in-state.

Historical Analysis: Construction Impacts

In forecasting the impact of network construction on Arkansas employment, income, and taxes, DRI used its Interindustry Model to determine the total direct and indirect demands on all industries to support Arkansas's construction plans. As a starting point, we determined which industries would most likely be called upon to meet the demand associated with network enhancements. We then used the Interindustry Model to estimate the indirect effects throughout the economy of the new construction work. (See the discussion of the DRI Interindustry Model for an explanation of direct and indirect effects.) Finally, the Interindustry Model provided an estimate of industry-specific job creation in response to these demand increases.

We assumed that the materials and equipment required by in-state suppliers to Southwestern Bell would be filled by other in-state manufacturers only in proportion to the size of the industry in Arkansas, relative to the nation. We assumed that half of all service inputs required by Southwestern Bell would be filled by in-state businesses. Under this assumption, we then solved the Arkansas State Model to obtain the multiplier effect, the dynamic by which increased demand for labor leads to more jobs, higher wages, more discretionary income, more consumer spending, more production to support sales to consumers, higher employment to support the increased production, and so on.

Future Benefits of Network Modernization

1. Estimating the Economic Benefits

DRI divided the task of estimating the economic benefits to Arkansas of network modernization and usage into two parts. The first of these, estimating the employment, income, and taxes that are supported under by network construction, required input from the Interindustry Model and the Arkansas State Economic Model. The second, forecasting the increase in Arkansas employment, income, and taxes generated by increased economic activity stemming from network-induced efficiency gains, combined key aspects of all three DRI models: the Telecommunications Input Substitution Model, the Interindustry Model, and the Arkansas State Economic Model.

In forecasting the impact of network construction on Arkansas employment, income, and taxes, DRI used its Interindustry Model to determine the total direct and indirect demands on all industries to support the investment scenario. As a starting point, we determined which industries would most likely be called upon to meet the demand associated with network enhancements. We then used the Interindustry Model to estimate the indirect effects throughout the economy of the new construction work. (See the discussion of the DRI

Interindustry Model for an explanation of direct and indirect effects.) Finally, the Interindustry Model provided an estimate of industry-specific job creation in response to these demand increases.

Before running the Arkansas State Economic Model to measure the impact of these new jobs on income, taxes, and income-related job growth, DRI made an assumption regarding the degree to which these demand increases are likely to be met within the state. We assumed that the materials and equipment required by Southwestern Bell and in-state suppliers to Southwestern Bell would be filled by in-state manufacturers only in proportion to Arkansas employment in each supplying industry relative to national employment in that industry. Under this assumption, we then used the Arkansas State Model to obtain the multiplier effect, the mechanism by which increased demand for labor leads to more jobs, higher wages, more discretionary income, more consumer spending, more production to support sales to consumers, higher employment to support the increased production, and so on. (On average, Arkansas industries account for 1.3 % of total U.S. manufacturing employment.)

The procedure DRI used to forecast Arkansas employment, income, and taxes resulting from telecommunications-induced cost savings represents the most sophisticated interaction between DRI's economic models of any phase of this analysis. First, we identified two scenarios of future telecommunications usage which we view as reasonable representations of a scenario in which the Stipulation occurs and a scenario in which the Stipulation does not occur.

Second, for each usage scenario, we used the Telecommunications Input Substitution Model to forecast the amount of labor, capital, and materials that will be replaced by increased telecommunications usage in each industry. Thus, for each industry, we obtained an estimate of future cost savings due to the assumed increase in telecommunications usage under each scenario. We then ran these results through the DRI Interindustry Model to measure the extent to which each industry can pass its cost savings on to its customer industries, and they to their customer industries, and so on. (See the Interindustry Model discussion for an explanation of direct and indirect cost savings.)

It is important to note how cost savings are represented in an interindustry framework. An interindustry or input/output framework is initially constructed in nominal terms. That is, each industry's purchases of goods, services, capital and labor are measured in the current dollar purchases; no inflation adjustment is made. This, in turn, is to ensure that, in current dollars, every purchase by one industry is matched by a corresponding sale by another industry. This is to insure that a fundamental tenet of input/output analysis--namely that all inputs (purchases) must equal all outputs (sales) -- is preserved for the initial nominal interindustry matrices. This also maintains the accounting identity that an industry's output, or

revenues, is equal to its costs plus its profits. (In input/output parlance, this is known as "columns summing to unity".)²⁹

In order to examine productivity gains, however, these nominal interindustry matrices must be inflation adjusted to yield real input/output matrices. For example, in a nominal input/output table, if an industry spent half as much on electricity in one year as it did in the previous year, you could not tell if that industry became more energy-efficient (i.e., it consumed half as many kilowatt-hours of electricity), or if the price it was charged for the electricity dropped, or a combination of both effects. As a result, one would be unable to determine whether demand for electricity had dropped. Unfortunately, changes in demand for goods and services is exactly what input/output models are used to assess.

Real input/output tables, on the other hand, eliminate the effect of a change in the price of electricity in this example. Thus, any decrease in the industry's usage of electricity in a constant dollar input/output matrix would have to be a real gain in energy efficiency. At the same time, however, since the industry is using less electricity per dollar of output, its real costs are *less than* its real output, and the columns no longer sum to unity. (One could force the column to sum to one by defining real profits as the residual of real costs and real output, but this would be arbitrary and would have no impact on an open input/output model such as DRI's.)

Our research into the effect of telecommunications on industrial efficiency shows that by using telecommunications, industries are able to decrease their real costs, and therefore increase their real efficiency. These real efficiency gains are those that are applied to the real input/output tables in the DRI Interindustry Model.

Before applying the Arkansas State Economic Model to these results, we mitigated the impacts to account for the fact that 1) some cost savings are not passed on to customers, but are either eroded by higher wage rates or passed on to shareholders, and 2) many supplies will still be purchased from out-of-state producers who will not have the advantage of Arkansas-specific cost savings.

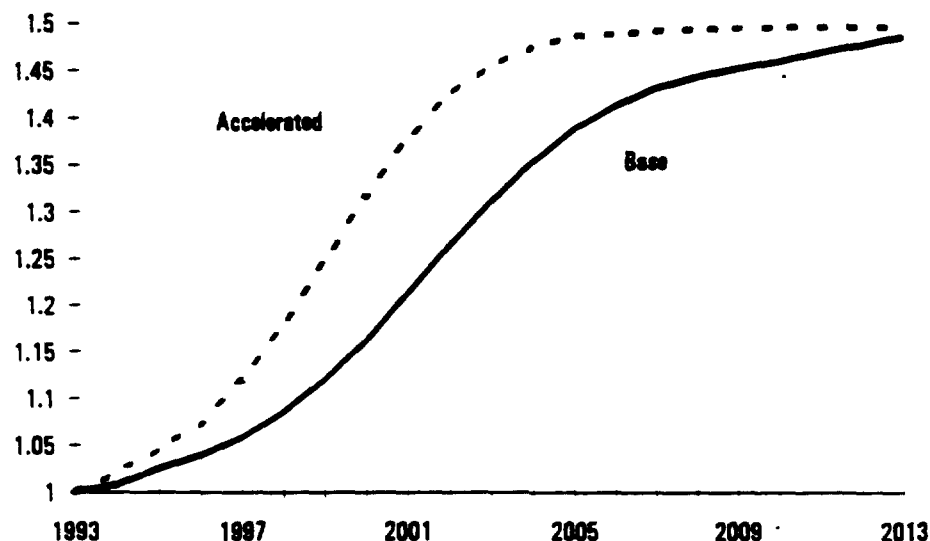
Once these constraints had been applied, DRI ran the Arkansas State Economic Model to estimate the impact of these industry-specific cost savings on jobs, income, and taxes. The model first established the link between cost-competitiveness and increased demand for the resulting lower-priced goods and services, and then generated the multiplier effect as described above. The model included a system of historical relationships that measured the extent to which incremental demands for labor and goods and services are likely to be met in-state.

²⁹ Mark Gold, "Note on the Difference in Accounting Identities between 'Current Dollar' and 'Real' Input-Output Tables," *Economic Systems Research*, Vol. 5, no. 1, (1993), pages 11-16.

2. Deriving the Usage Scenarios

To derive each usage scenario we first estimated an econometric equation that fit historical telecommunications usage to a Fisher-Pry technology substitution framework.³⁰ The Fisher-Pry model assumes that the adoption of a new technology over time follows an "S-Shaped" curve, where there is very little adoption in the early years, followed by rapid growth, and then a gradual leveling off. Using historical telecommunications usage as a guide we estimated a smooth, S-shaped curve that represents the historical pace of telecommunications adoption by U.S. industries. Figure VII-4-1 below shows the curves for each usage scenario. Notice that the curves extend through 2013.

Figure VII-4-1
S-Shaped Curve Representing
Business Intensity of Telecommunications Usage, 1993-2013
(Index, 1993 = 1.00)



³⁰ This diffusion pattern is described in the Fisher-Pry model. This model assumes that the adoption of a new technology over time follows an "S-Shaped" diffusion pattern, where there is very little adoption of technology in the early years, followed by rapid growth, and then a gradual leveling off. This framework was first introduced in 1970; over 95 substitutions in general industry have since been published. John Keith of NYNEX writes that "the [Fisher-Pry] model has found particular acceptance in the regulated telecommunications industry." See J.C. Fisher and R. H. Pry, "A Simple Substitution Model of Technological Change", General Electric Company, Report No. 70-C-214 (June 1970). See also Ralph C. Lenz, "Rates of Adoption/Substitution in Technological Change" (Austin, Texas: Technology Futures, Inc., 1985), page 4 in Appendix H. See also "Applications of the Fisher-Pry Substitution Model to Nonhomogeneous Technological Populations" by John W. Keith in *Technological Substitution in Transmission Facilities For Local Telecommunications*, by Lawrence K. Vanston and Ralph C. Lenz, (Austin, Texas: Technology Futures, Inc.) 1988, page 288.

We then applied this curve to the 1993 to 2002 period to project telecommunications usage under Scenario One--the "accelerated deployment" scenario. The Arkansas telecommunications intensity reflected by this curve grows at 4.0% from 1993 to 2002. The assumption of higher usage in this scenario reflects both the rate reduction associated with the Stipulation plan as well as the technology advancements promised from additional investments in the state's telecommunications infrastructure. DRI research shows that usage is closely associated with prices and technology. When telecommunications prices fall, telecommunications usage increases. When technology advances, the quality, reliability, and functionality of telecommunications services will increase. And, as the functionality of the telecommunications network improves, usage will, in turn, increase. Under the accelerated usage scenario, Arkansas industries would achieve substantial cost savings between 1993 and 2002 by substituting greater amounts of telecommunications services in place of less efficient inputs.

The "limited deployment" scenario represents a situation in which Southwestern Bell does not use the excess earnings to modernize the public network; hence, the degree of modernization in the Limited Deployment scenario is necessarily less than in Accelerated Deployment scenario. In this scenario, telecommunications usage grows at only 2.6% per year. Under this scenario, industries would be less able to utilize new telecommunications services as an efficient replacement for other inputs and would therefore fail to achieve the cost savings possible under the base case assumptions.

Consumer Subgroup Analysis

The framework for the consumer subgroup analysis is based on three sets of accounts: 1) the ability of U.S. industries to improve efficiency by increasing their usage of telecommunications, 2) the degree to which the price of telecommunications affects each industry's costs, and 3) the degree to which the budget of each consumer stake holder group is affected by these changes in industry costs. This section details how this information is used to estimate both the costs and the benefits of modernization to stake holder groups.

The benefits of modernization arise from the efficiency induced by increased telecommunications usage in U.S. industries. As previously discussed, the *DRI Telecommunications Input Substitution Model* measures the amount of telecommunications usage which may be substituted, in a cost-effective manner, for other inputs. Such substitution relations are determined for each of a comprehensive set of 30 industries through the estimation of industry-specific equation systems representing total costs, associated input shares, and industry output.

The interindustry model is used to estimate the ways in which cost savings in one industry may be passed to other industries, either directly or indirectly. The model details for 30 industries

the amount each industry purchases from the others in order to produce one unit of its own output. Such accounts can be linked together, since one industry's purchase is another industry's sale. Once linked, these accounts present an effective representation of the interdependence of the industries. The outstanding feature of the model is that it permits the calculation of the total direct and indirect derived industry output that must be generated to deliver a particular amount of output of a given industry to consumers, investors, the government, or export (i.e. GDP).

The precise industry interrelationships detailed in DRI's interindustry model enable one to trace how a change in productivity in one industry ripples throughout the economy. That is, the model can trace cost savings in one industry to cost savings throughout the economy. For this reason, the interindustry model presents a powerful tool to use in conjunction with the Telecommunications Input Substitution Model. If a modernized telecommunications network allows its users to cut production costs, the input substitution model (described above) yields an estimate of each industry's own cost savings as a direct result of its use of telecommunications. Since this model is industry-specific, however, it does not reveal how other industries might benefit from this cost decrease. The DRI Interindustry Model is used to estimate this indirect cost savings.

We also use the interindustry model to estimate how a business rate increase affects economy-wide prices. Just as a telecommunications-induced efficiency gain in one industry can be passed on to its customer industries in the form of lower prices, a telecommunications price increase can be passed from one industry to the next. Using the Leontief price model³¹ we can estimate how an increase in telecommunications prices directly and indirectly affect the prices for all goods and services in the economy.

The two models described above--the Telecommunications Input Substitution Model and the Interindustry model--provide the basis for estimating how industry prices are affected by changes in the usage and price of telecommunications. To estimate how individual consumer stake holders are affected by these industry price changes we use information on the purchasing patterns of these stake holders collected by the U.S. Bureau of Labor Statistic Consumer Expenditure Survey. Table VII-4-1 below shows the information from the consumer expenditure survey mapped to the 30 sectors used in this analysis. The consumer expenditures on each good or service is presented in nominal dollars in 1991, and as a percent of each consumer subgroup's total expenditures.

To estimate which consumer groups benefit from telecommunications modernization we combine information found from the Interindustry Model with the information on consumer expenditures found in Table VII-4-1. The Interindustry Model showed how costs in individual industries have been reduced as a result of increased telecommunications usage from 1965 to 1991. If a consumer's budget is concentrated in industries that historically have

³¹ Blair, Miller. *Input/Output Analysis: Foundations and Extensions*, ...

directly or indirectly benefited from increased telecommunications usage, then this consumer has benefited indirectly from the lower costs of the goods he or she purchases.

The impact of a change in business telecommunications prices is also estimated using the information from the Interindustry Model above along with the consumer expenditure information in Table VII-4-1. The Interindustry Model shows industries ranked according to the direct or indirect impact of telecommunications prices on each industry's costs. A consumer whose budget is highly concentrated in telecommunications-dependent sectors will be affected by an increase in business rates more than the average consumer. For example, the electronic equipment sector is significantly affected by a change in business telecommunications prices. Consumers who spend a significant portion of their budget on electronic equipment, such as stereos, televisions, and other home electronics, will be affected disproportionately by a change in business telecommunications prices. As Table VII-4-1 below shows, high income consumers spend proportionally more on the electronics sectors--i.e., 6.5% for high income consumers versus 6.0% for the average consumer.

Table VII-4-1
Consumer Expenditures by Consumer Subgroup
(1991)

	Lowest 20% of Income		Highest 20% of Income		Elderly		Average		Urban		Rural	
	1991\$	%	1991\$	%	1991\$	%	1991\$	%	1991\$	%	1991\$	%
Average Annual Expenditures	13,464	100%	57,597	100%	19,692	100%	29,614	100%	30,382	100%	24,785	100%
Housing	2741	20.4%	9621	16.7%	3119	15.8%	5191	17.5%	5533	18.2%	3040	12.3%
Food	2651	19.7%	7893	13.7%	3383	17.2%	4844	16.4%	4915	16.2%	4409	17.8%
Finance & Insurance	578	4.3%	9871	17.1%	1215	6.2%	3683	12.4%	3778	12.4%	3090	12.5%
Miscellaneous Services	1555	11.5%	4214	7.3%	2724	13.8%	2449	8.3%	2477	8.2%	2272	9.2%
Motor Vehicles and Equipment	670	5.0%	3963	6.9%	1109	5.6%	2111	7.1%	2106	6.9%	2142	8.6%
Textiles	912	6.8%	4026	7.0%	1132	5.7%	1950	6.6%	2028	6.7%	1463	5.9%
Electric & Electronic Equipment	726	5.4%	3759	6.5%	932	4.7%	1785	6.0%	1818	6.0%	1572	6.3%
Utilities	876	6.5%	1961	3.4%	1339	6.8%	1372	4.6%	1362	4.5%	1431	5.8%
Petroleum Refining	471	3.5%	1514	2.6%	600	3.0%	995	3.4%	960	3.2%	1215	4.9%
Business Services	361	2.7%	1705	3.0%	572	2.9%	860	2.9%	872	2.9%	788	3.2%
Automotive Repair	311	2.3%	1637	2.8%	552	2.8%	845	2.9%	863	2.8%	728	2.9%
Amusements	330	2.5%	1657	2.9%	533	2.7%	777	2.6%	817	2.7%	523	2.1%
Telecommunications	415	3.1%	834	1.4%	440	2.2%	618	2.1%	621	2.0%	601	2.4%
Transportation and Warehousing	162	1.2%	689	1.2%	233	1.2%	304	1.0%	325	1.1%	169	0.7%
Chemicals and Products	164	1.2%	563	1.0%	256	1.3%	301	1.0%	304	1.0%	283	1.1%
Furniture	109	0.8%	657	1.1%	139	0.7%	294	1.0%	305	1.0%	223	0.9%
Printing and Publishing	70	0.5%	309	0.5%	144	0.7%	163	0.6%	168	0.6%	134	0.5%
Paper and Paperboard	70	0.5%	215	0.4%	125	0.6%	123	0.4%	128	0.4%	92	0.4%

Source: BLS Consumer Expenditure Survey and DRI/McGraw-Hill

Note: Percentages may not add to 100 due to rounding. Cash Contributions category is not included in sectoral breakdown.

The impact of changes in residential rates is estimated using information on the purchases of telecommunications services by consumer sub-group found in Table VII-4-1 above. If a particular consumer sub-group spends a greater portion of its income on telecommunications, it will be affected more by a change in residential telecommunications rates. That is, the price that this group pays for its bundle of goods and services will increase proportionally more than the average consumer group. The Consumer Expenditure Survey conducted by the Bureau of Labor Statistics (see Table VII-4-1 above) indicates that telecommunications consumption patterns do vary across consumer subgroup, suggesting that an increase in residential rates would affect consumer subgroups differently.